

## PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:  
 Assistant Commissioner for Patents  
 United States Patent and Trademark  
 Office  
 Box PCT  
 Washington, D.C.20231  
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 04 October 2000 (04.10.00)	To: Assistant Commissioner for Patents United States Patent and Trademark Office Box PCT Washington, D.C.20231 ETATS-UNIS D'AMERIQUE  in its capacity as elected Office
International application No. PCT/AU00/00058	Applicant's or agent's file reference 26994WOP00
International filing date (day/month/year) 02 February 2000 (02.02.00)	Priority date (day/month/year) 02 February 1999 (02.02.99)
Applicant GALVIN, Kevin, Patrick	

1. The designated Office is hereby notified of its election made:

in the demand filed with the International Preliminary Examining Authority on:

29 August 2000 (29.08.00)

in a notice effecting later election filed with the International Bureau on:

\_\_\_\_\_

2. The election  was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland  Facsimile No.: (41-22) 740.14.35	Authorized officer  Charlotte ENGER  Telephone No.: (41-22) 338.83.38
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**PATENT COOPERATION TREATY**  
**PCT**  
**INTERNATIONAL PRELIMINARY EXAMINATION REPORT**

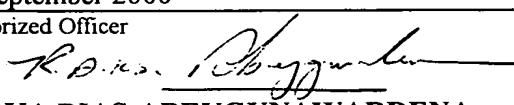
19 SEP 2000

PCT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference  26994WOPOO	<b>FOR FURTHER ACTION</b>	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).	
International application No.  PCT/AU00/00058	International filing date ( <i>day/month/year</i> )  2 February 2000	Priority Date ( <i>day/month/year</i> )  2 February 1999	
International Patent Classification (IPC) or national classification and IPC  <b>Int. Cl.</b> <sup>7</sup> B03B 5/62, B01J 8/20			
<p>Applicant  1 THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED</p> <p>2 GALVIN, Kevin Patrick</p>			

1.	This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.		
2.	This REPORT consists of a total of 4 sheets, including this cover sheet.		
<input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).			
These annexes consist of a total of sheet(s).			
3.	This report contains indications relating to the following items:		
I	<input checked="" type="checkbox"/> Basis of the report		
II	<input type="checkbox"/> Priority		
III	<input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability		
IV	<input checked="" type="checkbox"/> Lack of unity of invention		
V	<input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement		
VI	<input type="checkbox"/> Certain documents cited		
VII	<input type="checkbox"/> Certain defects in the international application		
VIII	<input type="checkbox"/> Certain observations on the international application		

Date of submission of the demand  29 August 2000	Date of completion of the report  12 September 2000
Name and mailing address of the IPEA/AU  AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929	<p>Authorized Officer    <b>ASOKA DIAS-ABEYGUNAWARDENA</b>  Telephone No. (02) 6283 2141</p>

## I. Basis of the report

## 1. With regard to the elements of the international application:\*

the international application as originally filed.

the description,      pages , as originally filed,  
                                  pages , filed with the demand,  
                                  pages , received on    with the letter of

the claims,                pages , as originally filed,  
                                  pages , as amended (together with any statement) under Article 19,  
                                  pages , filed with the demand,  
                                  pages , received on    with the letter of

the drawings,                pages , as originally filed,  
                                  pages , filed with the demand,  
                                  pages , received on    with the letter of

the sequence listing part of the description:  
                                  pages , as originally filed  
                                  pages , filed with the demand  
                                  pages , received on    with the letter of

## 2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language which is:

the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

the language of publication of the international application (under Rule 48.3(b)).

the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

## 3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, was on the basis of the sequence listing:

contained in the international application in written form.

filed together with the international application in computer readable form.

furnished subsequently to this Authority in written form.

furnished subsequently to this Authority in computer readable form.

The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4.  The amendments have resulted in the cancellation of:

the description,      pages

the claims,              Nos.

the drawings,            sheets/fig.

5.  This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\*

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

\*\* Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report

**IV. Lack of unity of invention**

1. In response to the invitation to restrict or pay additional fees the applicant has:
  - restricted the claims.
  - paid additional fees.
  - paid additional fees under protest.
  - neither restricted nor paid additional fees.
2.  This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is:
  - complied with.
  - not complied with for the following reasons:
4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:
  - all parts.
  - the parts relating to claims Nos.

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Claims 1-11	YES
	Claims	NO
Inventive step (IS)	Claims 1-11	YES
	Claims	NO
Industrial applicability (IA)	Claims 1-11	YES
	Claims	NO

**2. Citations and explanations (Rule 70.7)**

**NOVELTY (N):**

Claims 1-11

US 4493735 A (ERWIN FLASCHEL et al) 15 January 1985  
 Derwent Abstract Accession No 98-099263/09, Class J01,  
 RU 2083289 C1 (VOSTORG CO LTD) 10 July 1997

Derwent Abstract Accession No 88-160026/23, Class P41,  
 SU 1351674 A (ZLO BIN) 15 November 1987

Derwent Abstract Accession No 92-207402/25,  
 Class P41, P43, (MOSC TOOL-MAKING INST) 30 July 1991

None of the above citations discloses all of the features of the above claims.

**INVENTIVE STEP (IS):**

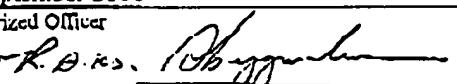
Claims 1-11 as above.

**PATENT COOPERATION TREATY**  
**PCT**  
**INTERNATIONAL PRELIMINARY EXAMINATION REPORT**

(PCT Article 16 and Rule 70)

Applicant's or agent's file reference 26994WOPOO	<b>FOR FURTHER ACTION</b>	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. PCT/AU00/00058	International filing date (day/month/year) 2 February 2000	Priority Date (day/month/year) 2 February 1999
International Patent Classification (IPC) or national classification and IPC Int. Cl. 7 B03B 5/62, B01J 8/20		
<p><b>Applicant</b></p> <p>1 THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED</p> <p>2 GALVIN, Kevin Patrick</p>		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 4 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheet(s).</p>																
<p>3. This report contains indications relating to the following items:</p> <table> <tr> <td>I</td> <td><input checked="" type="checkbox"/> Basis of the report</td> </tr> <tr> <td>II</td> <td><input type="checkbox"/> Priority</td> </tr> <tr> <td>III</td> <td><input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td> </tr> <tr> <td>IV</td> <td><input type="checkbox"/> Lack of unity of invention</td> </tr> <tr> <td>V</td> <td><input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</td> </tr> <tr> <td>VI</td> <td><input type="checkbox"/> Certain documents cited</td> </tr> <tr> <td>VII</td> <td><input type="checkbox"/> Certain defects in the international application</td> </tr> <tr> <td>VIII</td> <td><input type="checkbox"/> Certain observations on the international application</td> </tr> </table>	I	<input checked="" type="checkbox"/> Basis of the report	II	<input type="checkbox"/> Priority	III	<input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability	IV	<input type="checkbox"/> Lack of unity of invention	V	<input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement	VI	<input type="checkbox"/> Certain documents cited	VII	<input type="checkbox"/> Certain defects in the international application	VIII	<input type="checkbox"/> Certain observations on the international application
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VIII	<input type="checkbox"/> Certain observations on the international application															

Date of submission of the demand 29 August 2000	Date of completion of the report 12 September 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Faxsimile No. (02) 6285 3929	Authorized Officer  ASOKA DIAS-ABEYGUNAWARDENA Telephone No. (02) 6283 2141

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 00/00058

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int Cl: B 03 B 5/62, B01J 8/20 According to International Patent Classification (IPC) or to both national classification and IPC.		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) B 03 B 5/62, B01J 8/20		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU:IPC as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Derwent		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 493 735 A (ERWIN FLASCHEL et al) 15 January 1985 Derwent Abstract Accession No 98-099263/09, Class J01. RU 2 083 289 C1 (VOSTORG CO LTD) 10 July 1997	
A	Derwent Abstract Accession No 88-160026/23, Class P41, SU 1 351 674 A (ZLO BIN) 15 November 1987	
A	Derwent Abstract Accession No 92-207402/25, Class P41, P43, (MOSC TOOL-MAKING INST) 30 July 1991	
<input type="checkbox"/> Further documents are listed in the continuation of Box C		<input checked="" type="checkbox"/> See patent family annex
* Special categories of cited documents: "A" Document defining the general state of the art which is not considered to be of particular relevance "R" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 29 February 2000		Date of mailing of the international search report 14 MAR 2000
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No.: (02) 6283 3929		Authorized officer  <b>ASOKA DIAS-ABEYGUNAWARDENA</b> Telephone No.: (02) 6283 2141

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
PCT/AU 00/00058

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member	
US	4 493 735	AU	86099/82
		CA	1 192 383
		EP	70330
		JP	58024393

END OF ANNEX

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification<sup>7</sup> :</b> <b>B03B 5/62, B01J 8/20</b>		<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 00/45959</b> <b>(43) International Publication Date:</b> <b>10 August 2000 (10.08.00)</b>
<b>(21) International Application Number:</b> <b>PCT/AU00/00058</b> <b>(22) International Filing Date:</b> <b>2 February 2000 (02.02.00)</b>  <b>(30) Priority Data:</b> PP 8481 <b>2 February 1999 (02.02.99)</b> AU		<b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
<b>(71) Applicant (for all designated States except US):</b> THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED [AU/AU]; Industry Development Center, University Drive, Callaghan, NSW 2308 (AU).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> <u>GALVIN</u> , Kevin, Patrick [AU/AU]; The University of Newcastle Research Associates Limited, Industry Development Centre, University Drive, Callaghan, NSW 2308 (AU).  <b>(74) Agent:</b> BALDWIN SHELSTON WATERS; 60 Margaret Street, Sydney, NSW 2000 (AU).		<b>Published</b> <i>With international search report.</i>	
<b>(54) Title:</b> A REFLUX CLASSIFIER			
<b>(57) Abstract</b>  A reflux classifier for segregating particles by size or density uses a fluidized bed in a chamber (10). Arrays of inclined plates (14A, 14B and 14C) forming lamellae (12A, 12B and 12C) divide the chamber into zones into which particles of predetermined size or density migrate. Particle differentiation is controlled by plate length, inclination and spacing in each array, combined with fluidization rate. Both batch and continuous processes are described.			

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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<b>DK</b>	Denmark	<b>LR</b>	Liberia	<b>SG</b>	Singapore		

**TITLE: A REFLUX CLASSIFIER****TECHNICAL FIELD**

The present invention relates generally to a method or an apparatus for segregating or classifying particles. The invention relates particularly, though not exclusively, to a 5 fluidized multistage lamellae classifier, particle fractionator or reflux classifier, being designed for segregating particles according to size or density.

**BACKGROUND OF THE INVENTION**

In many industrial processes it is necessary to classify particles according to their size, and sometimes according to their density. For example, in mineral processing, 10 screens, cyclones, and elutriators are often used to sort particles prior to downstream beneficiation. Classification may proceed either in a wet or a dry state. Although the aim may be to separate the particles at a specific size, there is usually a high degree of so-called misplaced material, with a portion of coarse particles reporting with the fine particle stream. An "S" shape partition curve provides a measure of the probability of a 15 given particle size reporting to a given stream, and hence the efficiency of the separation.

In principle, sieves should provide the perfect separation, given that a particle will only pass through the sieve if it is smaller than the openings. However, if the particles are not given sufficient time on the sieve a poor separation will be achieved. Relatively fine particles, less than 45 $\mu\text{m}$  in diameter, readily adhere to other particles, and are 20 therefore difficult to separate using sieves. Sieves also tend to become blinded by particles which are similar in size to the openings, and operate poorly when particles are fed on a continuous basis.

Elutriators separate particles according to their settling velocity. If the particles are of the same density, then the separation proceeds in accordance with the particle size. A liquid passes up through the vessel at a specific velocity, carrying slower settling particles to the top, thus allowing faster moving particles to be withdrawn from near the 5 base of the vessel. However, elutriators fail to provide satisfactory throughputs, especially when the separation size is relatively small. On the other hand cyclones provide remarkably high throughputs although their efficiency is arguably poorer, and the separation size more difficult to control.

Inclined classifiers have the potential to offer satisfactory throughputs, and 10 efficient separations. Earlier this century Boycott (1920) found that the effective rate of sedimentation could be increased significantly by inclining a vessel. Lamellae thickeners, which are gravity settlers containing parallel plates, are now used in solid liquid separation. However with these known systems there is no attempt to classify particles, only to remove all particles from much of the liquid. Basically the solids settle 15 onto the plates once only and move downwards as a concentrate. In laboratories, inclined devices have also been used to classify particles according to both size and density.

## **SUMMARY OF THE INVENTION**

According to one aspect of the present invention there is provided a classifier for 20 segregating particles by size or density, said classifier comprising:

- a fluidization chamber adapted to contain a fluidized bed;
- fluidization means adapted to provide a flow of fluidization fluid into the fluidization chamber; and

one or more inclined plates mounted within the fluidization chamber positioned such that in use, particles elutriated by the fluidization fluid within the chamber are caused to be segregated above or below the plates according to their size or density.

Preferably, said one or more inclined plates comprises at least one array of inclined 5 plates.

Preferably, said array of inclined plates comprises an array of parallel equally spaced plates.

Preferably, said array of plates extends substantially horizontally across said fluidization chamber.

10 Preferably, two or more arrays of inclined plates are provided, each array being vertically spaced from the or each other array, and dividing the fluidization chamber into zones.

Preferably, the length of each plate in an array, the angle of inclination of the plates, and the spacing between plates in that array are selected to enable particles of a 15 predetermined size or density to pass through the array when elutriated at a predetermined rate by the fluidization fluid, while inhibiting particles of greater size or density from passing through the array.

In one form of the invention a feed fluid incorporating particles to be classified is fed into the fluidization chamber between two said arrays of inclined plates.

20 In another form of the invention the particles are fed into the fluidization chamber with the fluidization fluid.

According to another aspect of the present invention there is provided a method of classifying particles by size or density, said method comprising the steps of:

providing a fluidized bed within a fluidization chamber in which is positioned one or more inclined plates;

feeding the particles into the fluidized bed; and

withdrawing particles from the chamber at one or more predetermined locations.

5 Preferably, the chamber is provided with two or more arrays of said inclined plates, each array being vertically spaced from the or each other array thereby dividing the fluidization chamber into zones, and wherein the withdrawal of particles from the chamber comprises withdrawal from a selected one or more of said zones.

Preferably, said fluidized bed is provided with fluidization fluid at a predetermined 10 rate so as to achieve desired separation of sizes or densities above and below said inclined plates in combination with selected sizes, inclination and spacings of said inclined plates.

It is understood that increased particle segregation is largely produced through the use of the inclined plates and efficient classification achieved by the reflux effect of the 15 fluidization fluid whereby said fluid can repeatedly fluidize into the plates particles of a certain size and/or density.

Generally the particles and vast majority of the fluidization fluid are introduced to the fluidization chamber as separate streams. Alternatively the particles are incorporated in the fluidization fluid which may for example be in the form of a slurry.

20 Each array of parallel, equally spaced plates forms a lamellae which acts as an inclined hydraulic screen causing the particles of different size or density ranges to locate into different zones within the chamber.

Typically there are provided a plurality of lamellae within the housing or fluidization chamber. In one embodiment the plates of adjacent lamellae stages are, in the direction of flow of the fluidization fluid, oriented differently whereby progressively slower settling particles pass each adjacent stage. For example, the plates may be longer, 5 closer together and/or less steep in order to achieve this effect. In another embodiment the configuration of plates of adjacent stages is substantially the same for greater refinement of the separation process. It should be appreciated that other permutations of lamella plate sequences and arrangements are within the scope of the present invention.

Typically, there is provided an uppermost lamellae designed to prevent particles 10 from escaping the fluidization chamber together with much of the fluidization fluid. Thus, relatively fine particles can be removed or classified in a more concentrated form from beneath the uppermost lamellae.

It is believed that the system has the advantage of self-control. An increase in the feed rate does not require a change in the underflow rate to preserve the separation 15 condition. Keeping the underflow rate constant will simply cause the suspension concentration to rise, which automatically changes the underflow solids rate to the right steady state level. The change in hindered settling will cause a slight change in the separation size, but this change will be substantially less than the change in the feed rate. The separation size for a given device is altered simply by changing the fluidization 20 velocity.

A further advantage is the ease of underflow removal because of the high rate of fluidization made possible by the control achieved by the lamellae. Hence all particles (including those in the underflow) tend to be in a state of suspension.

Preferably the fluidization chamber or classifier housing is elongate and shaped generally square or cylindrical in cross section with the stages of lamellae plates spaced longitudinally along its length. More preferably the fluidization chamber or classifier housing is oriented upright with the fluidization fluid flowing generally upward. The 5 cross sectional area of the chamber may vary from one stage to the next to alter the relative separation size.

Generally the plates are inclined. Additionally or alternatively the fluidization chamber may be inclined, or parts of the chamber may be inclined to follow the overall shape of the various stages of lamellae plates.

10 Advantageously, the step of passing the fluidization fluid through the classifier can involve alteration of the fluidization rate to promote segregation of the particles largely on the basis of density.

In one form of the invention the method or apparatus for segregating or classifying particles is performed as a batch operation. Alternatively the method or apparatus is 15 operated in a continuous mode whereby the particles are continuously or intermittently added to the fluidization chamber or the classifier housing. In this case, the feed is separated into an underflow stream and, at least, an overflow stream.

Generally the fluidization fluid is water or another liquid. Alternatively the fluidization fluid is a gas. The particles may be provided dry, or wet as a slurry.

20 The term "particles" is to be understood to include solids, liquid droplets, and air or other gas bubbles.

Suspension removed from specific zones between sets of parallel plates will contain particles of a narrow size range. The system can be operated as a particle

fractionator in the batch or continuous mode, separating a feed into multiple size fractions.

In order to achieve a better understanding of the nature of the present invention several preferred embodiments of an apparatus for and a method of segregating or 5 classifying particles will now be described, by way of example only, with reference to the accompanying drawings in which:

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a diagrammatic representation of a known single layer inclined classifier;

10 Figure 2 is a diagrammatic vertical cross-section through one embodiment of a particle classifier according to the present invention operating in a batch mode;

Figure 3 is a diagrammatic vertical cross-section through another embodiment of a particle classifier according to the present invention operating in a continuous mode;

15 Figure 4 is a diagrammatic vertical cross-section through an embodiment with a varying cross-section fluidization chamber; and

Figure 5 is a diagrammatic vertical cross-section through an embodiment where chamber shape follows the lamellae.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENT**

By way of background theory a simple kinematic description of solids or particle 20 classification in an inclined device will now be described. A schematic representation of a single plate inclined classifier is shown in Figure 1. Feed solids or particles may enter near the base, producing fine solids or particles in the overflow, and coarse solids or particles in the underflow. The trajectory of a critical size particle which reports both to

the underflow and the overflow is shown. The solid particle gradually settles towards the incline as it is carried upwards. Finer solids or particles will report to the overflow, and coarser solids or particles will slide down the incline to the underflow.

The fluid moves through the device at a velocity  $U$ , and hence arrives in a time, 5  $t=L/U$ , where  $L$  is the plate length. During this time the solid particle moves at a velocity  $V\cos\theta$  normal to the incline, where  $V$  is the usual particle velocity, and  $\theta$  is the angle with the horizontal. Assuming a width,  $W$ , between the plates, then

$$V\cos\theta = W/t = WU/L$$

Therefore, the critical particle velocity is,

10  $V=WU/ (L\cos\theta)$

The value of  $V$ , at a given suspension concentration depends on the particle size, assuming the solid particle density is constant. This equation provides a basis for selecting the lamellae width, length and angle. Ideally, the angle should be about 60 degrees. Higher angles will not amplify the segregation as much. Lower angles may 15 lead to build up of solids or particles on the incline.

Since the particle of velocity  $V$  can segregate against a fluid of velocity  $U$ , the sedimentation enhancement is given by the ratio of  $U/V$ . That is,

$$U/V = L\cos\theta/W$$

and hence the increase in settling rate is given by the ratio of the projected settling area 20 to the cross-sectional flow area. By inclining a vessel with a long length  $L$  and narrow width  $W$  significant rates of separation can be obtained. A lamellae consisting of many plates separated by a narrow gap  $W$  has the potential to increase throughputs many fold.

A schematic representation of one embodiment of a particle classifier 10 operated in a batch mode is shown in Figure 2. When the bed is fluidized by introducing a fluidization fluid at 11, solids or particles move upwards into arrays of plate lamellae 12A, 12B or 12C, and settle out on to the respective inclined plates 14A, 14B or 14C.

5 The plate lamellae 12A, 12B or 12C are mounted within a fluidization chamber 16 which in this example is elongate and of a generally square cross-section. The finest grade of particle, however, passes up through. Some of the fine particles may deposit onto the inclined plates 14A, 14B or 14C and hence slide back down into a fluidized zone below the lamellae 12A, 12B or 12C. In time, these particles will again move up  
10 into the lamellae 12A, 12B or 12C and hence be given a second, third or subsequent chance to escape into the region above the lamellae 12A, 12B or 12C and hence the classifier operates as a reflux classifier. The fluidization process, therefore, helps to strip the suspension of the fine particles. The inclusion of the plate lamellae 12A, 12B or 12C into the fluidization chamber such as 16 to enhance segregation is an important feature  
15 of the invention. A common fluid velocity up through each of the channels formed between plates in a given lamellae is produced automatically because of the steady flow of the fluidization fluid, in this example water. This common velocity is important for achieving a sharp separation.

Once the particles move beyond the first stage of the plate lamellae 12A they then  
20 pass through a second lamellae 12B. This lamellae 12B consists, ideally, of longer plates 14B. The plates may also be oriented closer together or inclined with less of a gradient. Therefore, only the finest of the fine particles are capable of passing through the second stage 12B. Again, if these fine particles fail to pass through on the first

attempt, additional opportunities will be possible due largely to the reflux effect.

Additional lamellae may also be positioned above, such as 12C, with zones in between which are free of lamellae. For example the final or uppermost lamellae, in this case 12C, can be employed to prevent ultrafine particles from escaping the fluidization

5 chamber with the fluidization fluid.

The batch system will eventually produce a steady condition, with the finest particles trapped in the upper zones, and gradually coarser particles trapped in zones closer to the base. If the plate lamellae 12A, 12B and 12C were not used in the classifier

10, some segregation would occur. However, the applicant has observed that particles

10 covering a broad range of size tend to remain partially mixed in a conventional fluidized bed. Hence, in the absence of the plate lamellae a sharp separation may be difficult to achieve.

A schematic representation of another embodiment of the particle classifier operating in a continuous mode is shown at 110 in Figure 3. The particle classifier is

15 readily operated in a continuous fashion by providing a fluidization flow at 115 and pumping a particle feed slurry into an external feed well 180. An internal feed well may be preferred, but may be more difficult to incorporate because of the plate lamellae. The feed well 180 provides a means for disengaging unwanted entities such as air bubbles from the feed slurry. The feed slurry then ideally plunges into the middle zone 100 of

20 the classifier. In this embodiment plate lamellae 120C may be located above the feed entry position and a second stage lamellae 120B may be located below the feed entry position. For further refinement, additional lamellae such as 120A and 120D may be

used either side of the feed entry position. A lamellae free zone should exist between each set of lamellae 120A, B, C, and D. These zones classify via the reflux mechanism.

At the top of the fluidizing chamber 160 liquid containing the finer particles spill over into a launder (not shown) or are withdrawn via an outlet 200 for recovery in a 5 separate vessel (not shown). Alternatively the solids leave in a more concentrated form at outlet 300 from the zone between 120C and 120D. The coarser particles suspended near the base are pumped away to another vessel (not depicted) via outlet 400. The separation size is governed by the fluidization rate, together with the plate length, L, angle,  $\theta$ , and width, W, used in the lamellae.

10 In general, an increase in the suspension concentration below the plates results in higher concentrations within the plates, and hence segregation on the basis of density within the plates. With such segregation, it is possible to use the device to separate particles on the basis of density. Normally, the lower density particles will report to the overflow, and the higher density particles will report to the underflow. One way to 15 achieve a higher concentration and hence promote this mode of operation is to operate using a relatively low underflow concentration. In turn, the system naturally produces higher concentrations. The higher concentrations could also be achieved using lower fluidization velocities. Therefore, the device can also be used to separate particles on the basis of density.

20 It will be appreciated that solids or particles which are close to the separation condition have many opportunities to report to the correct position within the classifier such as 10 or 110. Further, the existence of plate lamellae such as 12 or 120 effectively amplifies the differences in particle velocities.

Although the fluidization chamber has been described in the embodiments above as typically square in cross-section and of constant cross-section throughout its height, it is also possible to vary the shape and cross-section of the chamber in order to provide additional control. For example, in Figure 4 there is shown a fluidization chamber 500 in which three arrays of lamellae 501, 502 and 503 are positioned in areas of the fluidization chamber 504 having differing cross-sections. By controlling the cross-section in this manner, the fluidization rate through each set of lamellae may be individually controlled even though there is a common fluidization rate supplied at 505 at the bottom of the chamber.

10 Figure 5 illustrates a further embodiment in which the fluidization chamber 600 incorporating arrays of lamellae 601 and 602 has angled side walls in the regions corresponding with the lamellae. For example the side walls in region 603 are angled to conform with the angle of inclination of the plates in lamellae 601, and similarly the side walls in region 604 are angled to correspond with the angle of inclination in lamellae 15 602. It is preferred that the zones 605 between lamellae remain with substantially vertical side walls. This configuration is particularly advantageous in reducing or eliminating any "dead" areas at either end of the lamellae between the inclined plates and the chamber walls.

20 The classifier and method of particle segregation or classification is suitable for feeds containing particles up to about 5 mm in diameter although larger particles could also be used. Ultrafine particles, less than 45  $\mu\text{m}$  in diameter also separate effectively, assuming colloidal aggregation is not a problem. Further it is possible to classify particles into different distinct fractions using either batch or continuous conditions. For

ultrafine particles, this is especially attractive. Hence the classifier and method of classification provide an excellent alternative to a conventional cyclosizer.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. The 5 classifier including a fluidization chamber may be of practically any configuration where essentially it operates as an elutriator or fluidized bed with the presence of one or more inclined plates typically arranged in one or more sets of lamellae. The method of segregating or classifying particles may also extend to the following applications:

- i) the classification of particles less dense than the fluidization fluid where 10 the described system operates in reverse with the fluidization fluid flowing downwards and the particles settling upwards;
- ii) gas fluidization of relatively fine particles;
- iii) the segregation or classification of liquid droplets or air bubbles such as that required in the draining of a foam in foam fractionation.

15 All such variations and modifications are to be considered within the scope of the present invention the nature of which is to be determined from the foregoing description.

**CLAIMS:**

1. A classifier for segregating particles by size or density, said classifier comprising:
  - a fluidization chamber adapted to contain a fluidized bed;
  - fluidization means adapted to provide a flow of fluidization fluid into the

5 fluidization chamber; and

one or more inclined plates mounted within the fluidization chamber positioned such that in use, particles elutriated by the fluidization fluid within the chamber are caused to be segregated above or below the plates according to their size or density.
2. A classifier as claimed in claim 1 wherein said one or more inclined plates

10 comprises at least one array of inclined plates.

3. A classifier as claimed in claim 2 wherein said array of inclined plates comprises an array of parallel equally spaced plates.
4. A classifier as claimed in either claim 2 or claim 3 wherein said array of plates extends across said fluidization chamber.

15 5. A classifier according to any one of claims 2 to 4 wherein two or more arrays of inclined plates are provided, each array being vertically spaced from the or each other array, and dividing the fluidization chamber into zones.

6. A classifier as claimed in claim 5 wherein the length of each plate in an array, the angle of inclination of the plates, and the spacing between plates in that array are

20 selected to enable particles of a predetermined size or density to pass through the array when elutriated at a predetermined rate by the fluidization fluid, while inhibiting particles of greater size or density from passing through the array.

7. A classifier as claimed in any one of claims 2 to 6 wherein a feed fluid incorporating particles to be classified is fed into the fluidization chamber between two said arrays of inclined plates.

8. A classifier as claimed in any one of claims 1 to 6 wherein the particles are fed into 5 the fluidization chamber with the fluidization fluid.

9. A method of classifying particles by size or density, said method comprising the steps of:

providing a fluidized bed within a fluidization chamber in which is positioned one or more inclined plates; and

10 feeding the particles into the fluidized bed and withdrawing particles from the chamber at one or more predetermined locations.

10. A method as claimed in claim 9 wherein the chamber is provided with two or more arrays of said inclined plates, each array being vertically spaced from the or each other array thereby dividing the fluidization chamber into zones, and wherein the withdrawal 15 of particles from the chamber comprises withdrawal from a selected one or more of said zones.

11. A method as claimed in either claim 9 or claim 10 wherein said fluidized bed is provided with fluidization fluid at a predetermined rate so as to achieve desired separation of sizes or densities above and below said inclined plates, in combination with 20 selected sizes, inclination and spacings of said inclined plates.

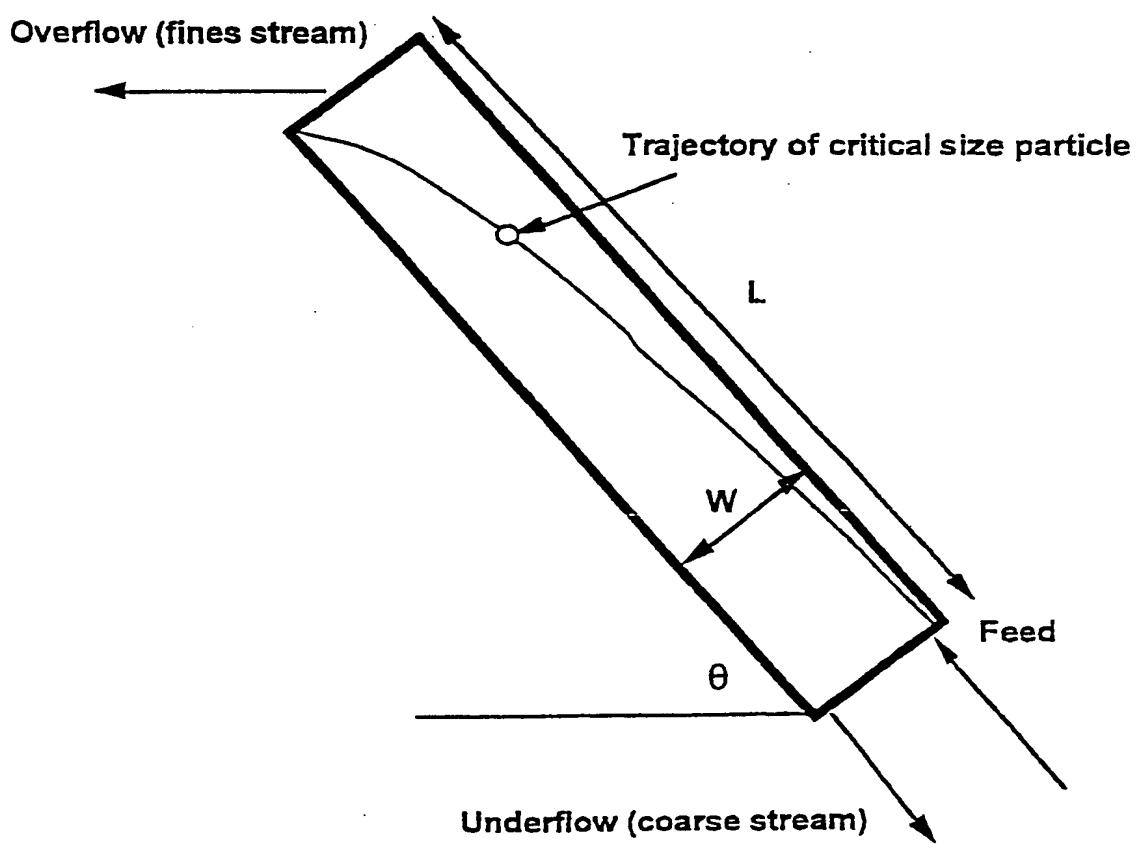


FIG. 1

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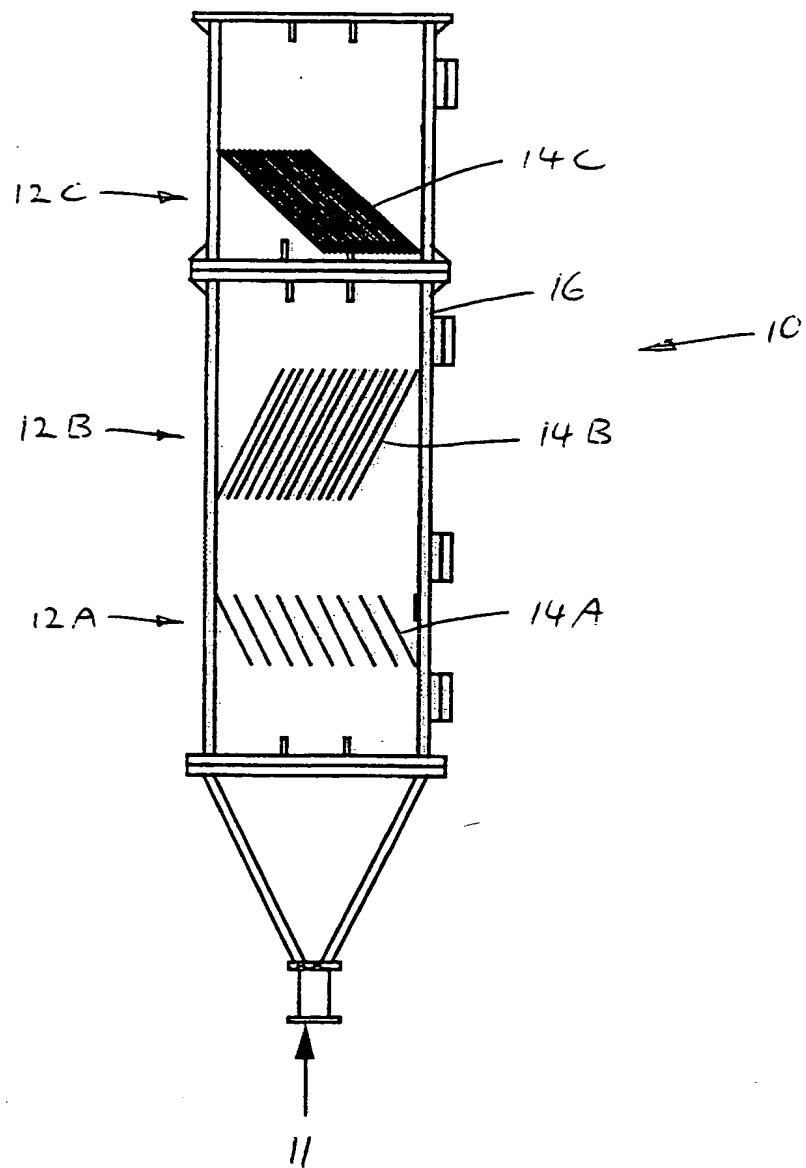
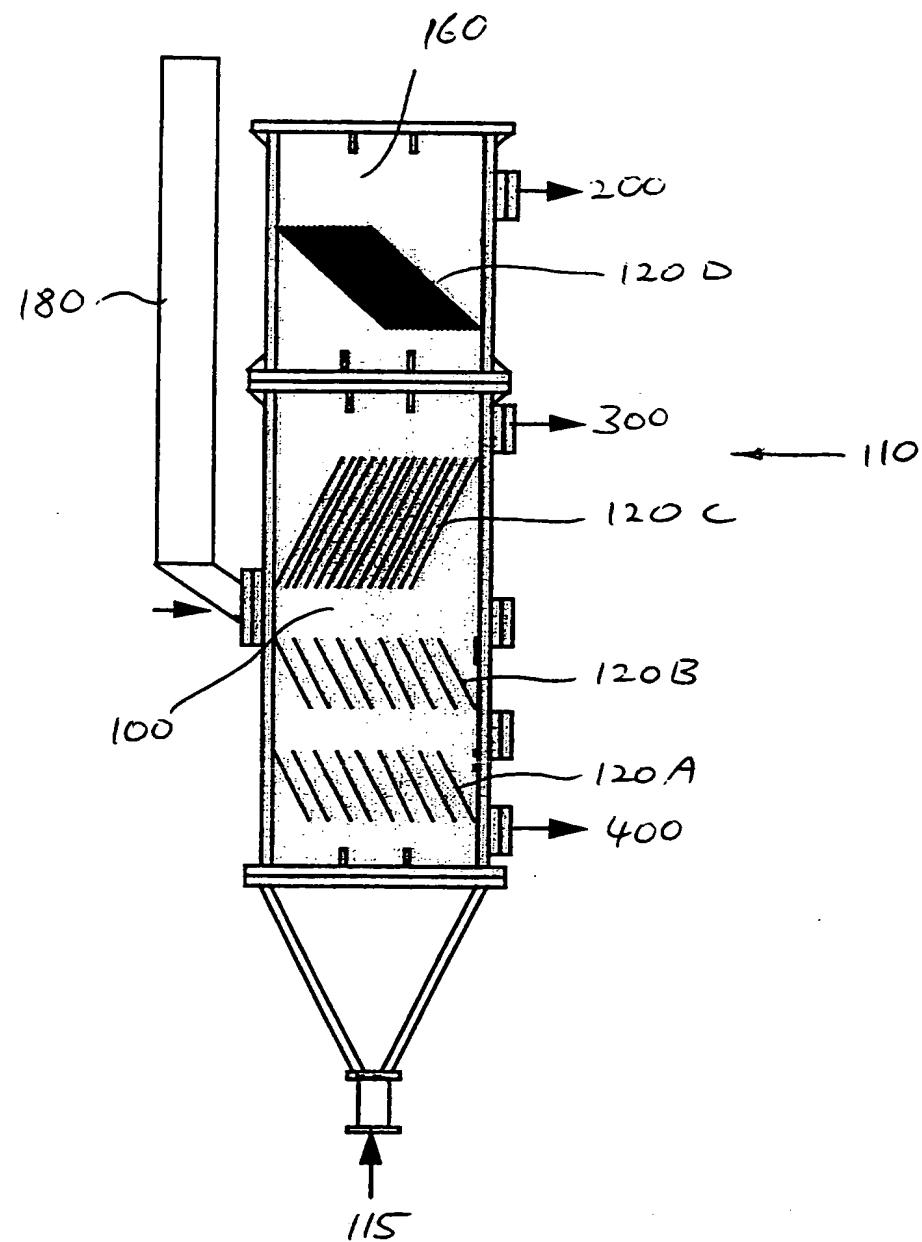


FIG 2

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FIG 3

4/5

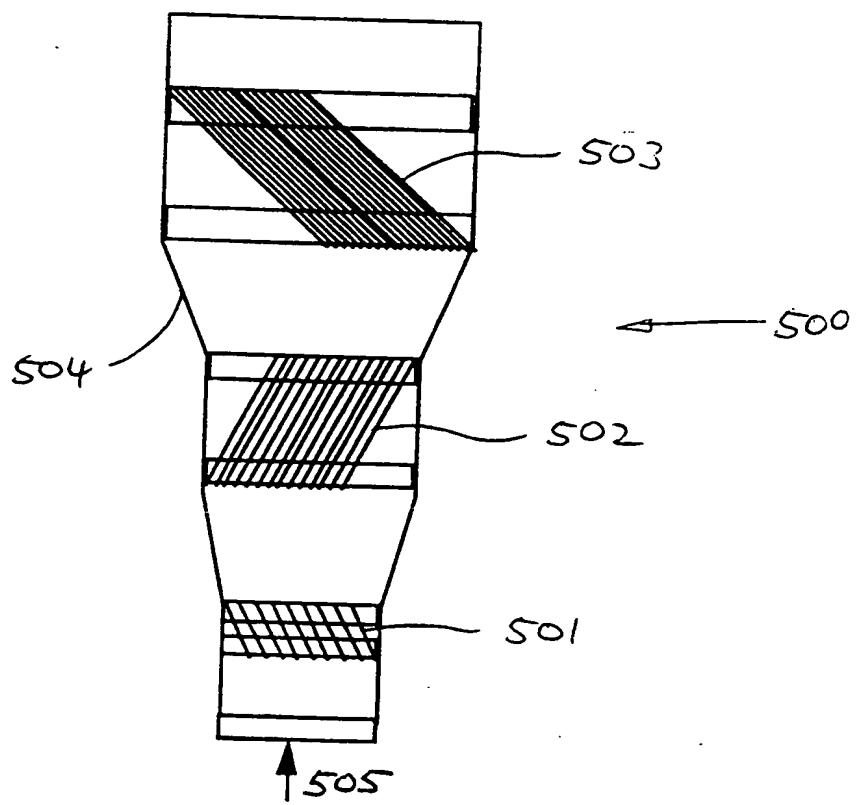


FIG 4

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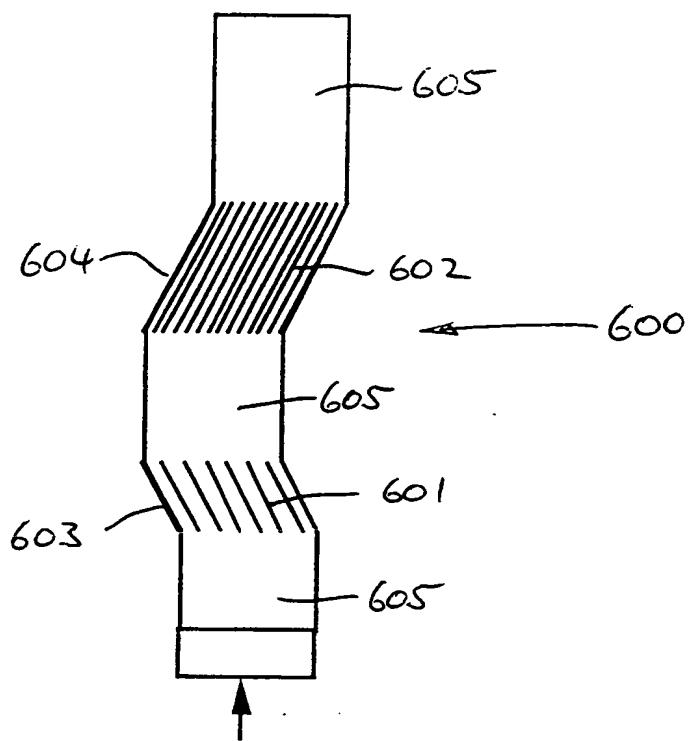
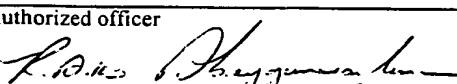


FIG 5

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/AU 00/00058

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int Cl <sup>7</sup> : B 03 B 5/62, B01J 8/20		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) B 03 B 5/62, B01J 8/20		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU:IPC as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Derwent		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 493 735 A (ERWIN FLASCHEL et al) 15 January 1985 Derwent Abstract Accession No 98-099263/09, Class J01, RU 2 083 289 C1 (VOSTORG CO LTD) 10 July 1997	
A	Derwent Abstract Accession No 88-160026/23, Class P41, SU 1 351 674 A (ZLO BIN) 15 November 1987	
A	Derwent Abstract Accession No 92-207402/25, Class P41, P43, (MOSC TOOL-MAKING INST) 30 July 1991	
<input type="checkbox"/> Further documents are listed in the continuation of Box C		<input checked="" type="checkbox"/> See patent family annex
* Special categories of cited documents: "A" Document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention		
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone		
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art		
"&" document member of the same patent family		
Date of the actual completion of the international search 29 February 2000		Date of mailing of the international search report 14 MAR 2000
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No.: (02) 6285 3929		Authorized officer  ASOKA DIAS-ABEYGUNAWARDENA Telephone No.: (02) 6283 2141

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/AU 00/00058**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member	
US	4 493 735	AU	86099/82
		CA	1 192 383
		EP	70330
		JP	58024393

END OF ANNEX